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AGRICULTURAL SERIES.

CULTIVATION OF SUGAR-BEET IN NORTH INDIA.

BY

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Introduction.

During 1899 and 1900 several enquiries reached the Agricultural Department as to the possibility of growing sugar-beet in these provinces. Experiments were therefore started at Cawnpore experiment station, and at the Saháranpur Gardens, while trials were made independently by Pandit Sundar Lal of Bhawalpur, who was kind enough to communicate some of his results. The information derived from these experiments is given in this bulletin. It will be seen that attempts to make *gur* by the ordinary methods were complete failures, and it seems probable that this must be the case, as unrefined beet-sugar made in Europe retains certain organic matter which gives it an unpleasant flavour. The writer of the bulletin therefore assumes that if beet is grown it will be on the central factory system, the cultivator receiving an advance and engaging to grow beet, the roots to be taken over by the factory.

The trials now reported, being for a single year, cannot be taken as indicating the best possible results, it is probable that with more experience the outturn could be considerably improved both in quantity and quality.

The difficulty of storing the roots through the hot weather is however a serious matter; the necessity of spade-cultivation to get the requisite depth of tillage makes it doubtful whether a factory could command a sufficient area of suitable land within a reasonable distance to enable it to work at a profit; and it is still doubtful whether seed can be properly matured.

On the whole it appears probable that for these provinces beet has no advantage over sugarcane: the tillage and manuring required for beet would give at least equally good results if devoted to cane.

W. H. MORELAND,

Cultivation of Sugar-beet in North India.

THE object of this bulletin is to place before the public a record of the results obtained in trials of the sugar-beet in these provinces, together with plain directions for the cultivation of the crop

Climate.—Those parts of North India where wheat and potatoes thrive may be taken to possess a climate suitable for the growth of beet The western districts, where the cold weather is comparatively prolonged and favours a softer and whiter variety of wheat, are probably more suitable than those further east.

Soil.—In Europe where the cultivation of sugar-beet originated and is practised on an extensive scale, well-drained, deep friable loams are most sought after The physical characters needed are porosity of surface and sub-soil to allow drainage of superfluous water, free circulation of air, and absorption and retention of plant food in condition suitable for ready assimilation This description applies generally to the light-coloured alluvial loam north of the river Jamna except where the soil is stiff or is low-lying and submerged during the rains. The garden soils round the larger towns, and the better village lands which produce maize, sugarcane and wheat may generally be assumed to be suitable for beet Stiff clays, regular rice-lands, the low-lying lands devoted to the harder and inferior varieties of cane, the poorer lands sown with inferior food crops, and those irrigated from canals by flow are not suitable.

Varieties.—The number of varieties is very great, and definite advice as to the kinds most suited for this country cannot be given on the results of a single year. It would probably be the best course for persons intending to try the crop to put themselves in the hands of Messrs. Vilmorin of Paris or some other equally reliable firm of seedsmen So far as our results go, Messrs. Vilmorin's varieties appear to have been most successful in these provinces.

Preparation of the land.—To obtain long, clean, properly-shaped roots the plants must have a sufficient depth of soil to grow in, as nothing fosters the development of side roots more than the stoppage of direct growth in the tap-root by the hardness of the sub-soil. In Europe and America success in the growth of sugar-beet is considered impossible unless the land be thoroughly and deeply worked so that the roots may have a sufficiently friable soil to a depth of about 14 to 16 inches in all. In these countries this is secured by the plough working to a depth of about six to ten inches followed by a sub-soiler going six or seven inches deeper. In this country the ordinary tillage implements in the possession of the cultivator can in no way be made to work this depth of soil, or anything like it. The only course possible for the cultivator is to adopt the method followed by the better cultivators near Cawnpore or Farukhabad, in preparing land for potatoes, to dig the land with the *phaora*, getting the requisite depth by two strokes on each spot, and by using the longer and narrower tools specially kept for potato cultivation. By this means he can break the land to a depth of about eight to ten inches, and in rare cases up to twelve inches; and if this operation be done about the beginning of July the further pulverisation of the soil can be effected with the country plough worked as often as possible, as is done by the better cultivators for their sugar-cane or wheat.

At the Cawnpore experiment station the land was ploughed to a depth of about five inches with the Watt's plough in the furrow of which a heavy plough of English make, with the mould-board removed followed, drawn by a pair of good bullocks, cutting the soil to a depth of about six inches more, thus giving a total depth of about eleven inches. The subsequent pulverisation was effected with the Planet Jr. cultivator fitted with narrow tines with a view to work the soil as deep as possible. The tilth obtained was fair, reaching a depth of about 10 or 11 inches, and was certainly better than what is possible for the ordinary cultivator with his present implements alone. And yet it seemed from the shape of the roots after digging out, and from the appearance of the growth above ground that the crop would have been better off a greater depth of friable soil had been available for it. It is

well-known to all beet-growers that if the tap root be not able to penetrate readily into the sub-soil but gets a check in its downward growth, it throws out many fibrous branched roots or gets forked, the whole of the root is not buried in the ground which lessens its proportion of sugar, and the crop also runs too much to tops Too much attention cannot therefore be given in getting to the proper depth in the preparation It is also well to recognise from the outset that the preparation of the soil for sugar-beet has to be much deeper and more thorough than what the cultivator gives to any of his crops at present

Manuring.—Sugar-beet requires specially a good supply of *readily available nitrogen*, so that the greater part of this ingredient may be absorbed by the crop in the early period of its development To secure this condition in the present state of Indian agriculture the main reliance in the case of the garden soils near towns must be on thorough tillage to be begun as long as possible before the time of sowing, say from February to June, and in any case not later than the beginning of July; and in the case of lands which need manuring, to apply cattle dung, poudrette, castor cake, or any other organic manure that may be available. The manure should be put on the land between February and May and the tillage continued so that a sufficiency of the nitrogen of the organic manure may be readily available for the crop from its commencement and that most of it may be absorbed at the right time Otherwise when organic manure is applied about the time of sowing the result will probably be that a rank growth of leaves and tops will be produced, maturity will be delayed, and the roots will contain a smaller percentage of sugar Effects of this nature were apparent in the trial at the Cawnpore station on the plots that were top-dressed with poppy seed refuse, a stimulating nitrogenous manure, and their occurrence is well-known and recognised in practice by the beet-growers of Europe. As a general rule it might be even safer and better to apply all organic manures to the previous crop of the rotation, thus bringing the land into good manurial condition and then to grow the beet on the strength of the manurial residue converted into a more available form by thorough tillage begun sufficiently early in such a case up to

about 10 to 15 tons of cattle manure or poudrette or up to about a ton of castor cake per acre may be applied to the previous crop But in case these manures are applied for the beet itself between February and May, not more than half the above quantities need be used.

On poor soils which have not been otherwise manured, up to about 4 maunds of the better grades of the bazar saltpetre may be spread on the land mixed with equal parts of earth before sowing the seed But in using saltpetre great care in selecting it will be necessary as the large proportion of common salt which exists as an impurity in the saltpetre ordinarily met with in the bazars will injuriously affect the quality of the beet For the same reason-applying with greater force owing to the much larger proportions of common salt in it, the crude saltpetre earth, now commonly used in some places for sugar-cane and other crops, can never be thought of in connection with sugar-beet.

Place of beet in the existing rotations—In the garden soils near large towns the richness of the soil and the facilities of labour for digging with the *phaora* will admit of a crop of beet after removing a crop of maize grown for selling the cobs green This will allow about a month and half to two months for preparing the land for beet Of course if the land be kept fallow for beet after removing *paunda*, potatoes, or tobacco of the previous season, better crops of beet could be obtained, but it will rarely pay the cultivator to do this, paying as he does for these lands a yearly rental of Rs. 50 and up to Rs. 100 per acre The beet may be followed in the next year by maize and afterwards by potatoes, but there will not be time to sow either *paunda* or tobacco

In the better village lands where sugar-cane is grown the present practice in many of the villages is to take a crop of wheat, or less commonly maize and then wheat, after removing cane. In these lands beet should follow the cane in the next year, neither the fertility of the soil nor the tillage resources of the cultivator will admit of an intermediate crop of maize.

Similarly in the case of the better wheat lands, the land should be fallow being worked at the time till the sowing of

beet From these remarks it will be seen that except in the minor case of the very rich garden lands, beet requires the field to be reserved for it the whole year, and that therefore the idea entertained in certain quarters to the effect that a kharif crop can be grown previous to beet is not practicable. In the exceptional case of the rich lands near towns the cultivation of beet would involve the abandonment of a crop of *pawanda* or tobacco.

Sowing—About the middle of October would be the most suitable season to begin the sowings, which may ordinarily continue up to the beginning of November, and in special cases up to the 15th November and not later. But in the western districts, as Meerut, Saháranpur, etc, the sowing can commence about a week or so earlier with less fear of the young seedlings getting injured by the sun The land may either be ridged up as for potatoes and the seed sown on the ridges, or it may be sown in drills in flat beds. In the former method there will be found some advantage while irrigating the crop in the early stages so as to give enough water and avoid giving too much In both cases the distance between the lines may be about 15 or 16 inches, and on the lines the seed should be dibbled with the hand almost continuously. In order to hasten germination the seed should be soaked before sowing in a mixture of equal parts of cattle urine and water for 24 hours. Immersion for a longer period is injurious, as thereby the seeds are likely to lose their soluble constituents The seeds when taken out of the mixture should be mixed with some finely pulverised wood ashes or cowdung ashes, dried on the surface and then sown.

If the seed-bed be moist enough on the surface, it is sufficient to cover the seed with earth to the thickness of an inch, if the seed-bed is drier the depth must be increased up to two inches If the condition of the seed-bed be such that even at two inches the soil is not moist enough for germination, it will be found a safer and better practice to irrigate once before sowing, and when the field is ready to work it with a cultivator or with the native plough and then sow. About 15 to 20lbs of seed would be required for an acre.

Thinning and after-cultivation.—When the plants show four leaves the work of thinning should be done In th

rich lands near large towns each plant may be allowed a space of about seven or eight inches, in all other lands the space allowed for an individual plant should be five or six inches, certainly not more than seven inches By allowing more room the number of roots, and consequently the weight of outturn, will become lower, and the individual roots will be larger and poorer in sugar as it is an axiom in beet cultivation that the smaller roots are richer within certain limits in sugar. The aim should be to produce well-shaped roots weighing not less than 1½lb and not more than 2½lbs in weight. When the roots are very small, the proportion of woody matter becomes excessive, and in Europe some factories reject roots weighing less than ¾lb. For the accepted roots the prices are paid according to the proportion of sugar in them as shown by chemical analysis or inferred from the density of the juice. The necessity for and the fairness of this process of valuation will be seen when it is considered that for producing 100lbs of sugar will be required

1,333 lbs of beet root containing			12½ per cent	cane-sugar
1,593 „ of	do.	do	11 per cent.	do.
2,213 „ of	do	do.	9 per cent	do.

Thus to the manufacturer 2,213lbs of roots of 9 per cent. sugar-content have the same value as 1,333lbs of roots containing 12½ per cent sugar; and he will pay about the same price for the former weight as for the latter.

On the richer lands care will be needed in preventing the roots from getting too large and watery and in the poorer lands from becoming too small and woody

At the time of thinning, any blanks in the line should be filled by transplanting young and vigorous plants from the crowded parts of the lines. The sooner the operations of thinning and transplanting are performed the better: by delaying the former the individual plants are crowded and hence insufficiently fed during the early stages, while if transplanting is delayed, it becomes impossible to extract the young root without breaking it or to prevent the resulting beet from being forked

Weeding and hoeing by hand should be done at least three times so as to keep the land clean and free of weeds, and the surface soil stirred and loosened to admit a free percolation of air. The first hoeing may be done with the thinning when the crop is about

three or four weeks old, the second hoeing about a month later, and the third after a further interval of about a fortnight During the second and third hoeings the plants should be carefully earthed up as is done for potatoes. In European practice the prescription is "hoe as often as you can, say at least once a fortnight during growth;" but in this country from three to five times will be the practicable limit in most cases.

Irrigation should be given during the growth of the crop from five to eight times according to the nature of the season: if the season is dry and the crop needs them, the oftener the waterings are given the better will be the results.

Some growers remove the leaves during the later stages in the growth of the plant but experience and exhaustive experiments have proved that this practice does no good and is attended with injury to the crop.

Ripening and Harvesting.—The roots should not be dug out till quite ripe This stage is marked by the leaves turning yellow and withering. One test recommended in books is to cut a root in two with a knife The newly-cut surface in the case of an unripe root rapidly changes colour on exposure to the air, but if the root is ripe the surface remains unchanged or turns only slightly reddish If it is found by the appearance of the leaves or by this test that some roots have ripened and others have not, there will probably be no harm to the ripe ones by allowing them to remain in the soil for a few days more till the whole field is quite ripe unless there is any risk of rain.

The roots may be dug out with *phaoras* and then removed by hand, but great care should be taken that none of the roots are cut or bruised, otherwise they will be liable to decay while in store. The roots should be well shaken in order to get rid of all earth adhering to them The leaves should be removed from the roots by means of a knife, taking care not to cut any part of the root except the neck The object of removing this portion of the plant is to prevent the mineral salts which have accumulated therein in large quantities from entering the factory, as these minerals exercise a very deleterious influence on crystallisation of cane-sugar.

Outturns.—The following table gives the results obtained at Saháranpur Cawnpore and Bahawalpur

Outturns of sugar-beet grown in Northern India from imported seed

Locality	Variety	Treatment	Yield per acre: Leaves	Yield per acre: Roots	Percentage of Cane sugar in roots	Approximate quantity of cane-sugar per acre calculated from percentage.	Remarks
			lbs	lbs		lbs	
Saharanpur	1 White green-top Brabant	Sown in rich loam ordinarily used for growing vegetables and heavily manured with butter refuse	18,276	28,169	9 91	2,800	
	2 White red top		8 163	24,415	10·28	2,800	
	3 Klein wanzlieben ...		11,718	24 151	8 77	2,100	
	4 French, very rich		16,975	20,183	12 10	2,500	
	5 White grey top (Lane's improved)		15,719	19,514	11 17	2,200	
	6. Yellow Sugar-beet		11,806	17,559	9·75	1,700	
	7 White improved Vilmorin.		12,068	16,301	12 52	2,000	
Cawnpore	White improved Vilmorin	1 Poudrette at 200lb Nitrogen per acre	14,140	15,666	Large roots 10 05 Medium roots 13 40	1,800	Rich land equal to the garden soils
		2. Poudrette at 100 lb Nitrogen per acre	12,544	21,952	Average 11 72	2,600	
		3 Poppy seed refuse 1,400 mds per acre	10,968	11,976			
		4. Poppy seed refuse 150 mds per acre	3,016	5,168	Large roots 13 15 Medium 16 77	1,800 800	Land in condition of good cane land Ordinary wheat land
		5 Unmanured	5,096	11,328	Average 14·88	1,700	Good cane land
		6. Unmanured ...	2,720	4,384	...	700	Ordinary wheat land
Bahawalpur	Unknown		*Not recorded*		*Varied from 9 88 to 13 09*		

The foregoing statement brings out clearly the necessity for heavy manuring. The factors determining the value of the crop are first the weight of roots, and second the percentage of sugar. From these figures the theoretical yield of cane-sugar has been calculated. The figures do not of course represent the weight of sugar which would actually be obtained, as deductions must first be made for glucose and ash, but they afford a fair basis for comparison.

It will be seen that on the highest class of soils the amount of sugar so calculated varied from 1,700 to 2,800lbs., on the intermediate lands the yield was 1,700 to 1,800lbs, while on ordinary wheat land it was only 700 to 800lbs per acre.

One point of interest and practical importance as well that deserves attention in reading through the figures of outturns obtained at Cawnpore and Saharanpur is the high proportion of the weight of leaves to that of roots. At the former place the leaves were about 60 per cent to 93 per cent of the weight of roots, and at Saharanpur the proportions (except in the case of white rod top) were very similar; while the published results of the experiments at Rotham-stead show about 20 to 30 per cent which is probably about the proportion accepted as normal on the continent. To what extent such a high proportion of leaves is incidental to the Indian climate is a point that remains to be decided, but the inferences that this proportion is a sign of the adverse manurial condition of the soil, and possibly also of insufficient depth of tillage, and that the crops were probably rank in growth and not fully ripe at the time of harvesting, appear highly probable.

Storage of roots.—A factory working on modern lines must in order to command success be on a large scale and the working season must extend over several months in order to earn interest on the capital invested. A large part of the crop must therefore be stored after being gathered. During storage the great dangers are (1) the roots rotting, (2) a renewal of active vitality which involves a loss of sugar. Rot is usually introduced by a wound on a root, with a suitable temperature it spreads rapidly throughout the heap in store. Renewal of vitality will also depend mainly on temperature. To prevent both these adverse effects

and to preserve the roots in the fresh state they should be stored at a low temperature 35° to 40° F is considered the most suitable temperature for the purpose, at any rate not more than say 50° F. Possibly deep cellars with special refrigerating contrivances would be successful in these provinces but this point must be carefully worked out by any one desirous of taking up the industry In this connection it should be borne in mind that in Europe the winter is the storing season, while in North India the crop would be harvested in April and would be stored during the hottest months of the year.

Seed—In the experiments at Cawnpore the sowings were rather later than was desirable, and it was impossible to produce seed At Saharanpur the seed is being secured but further experience is needed to decide whether it will be fit for sowing Whether seed could be obtained with earlier sowing in ordinary districts is a question that awaits solution it could scarcely pay to import seed every year. It is also a question whether the improved beets would maintain their characters if reproduced in this country In this respect the present experience with imported garden beets, carrots, etc is that they lose their superior characters unless the seed be obtained fresh from Europe In this direction some of the superior European varieties will need not only acclimatisation but careful and patient improvement by selection, etc on the lines adopted by the seedsmen of Europe This work will necessarily devolve on the central factory, as if the selection of seed be left in the hands of the cultivator he is not likely to pay that scrupulous attention to the superiority of the variety which is an essential condition for the success of the beet industry in any country

Manufacture of gur—Attempts were made at Cawnpore and Saharanpur to make *gur* from sugar-beets, by simple methods which could be practised by cultivators, the resulting product was a dirty-looking disgusting stuff which is utterly unfit for consumption, and which, on being analysed by Dr Leather, proved, as will be seen from the tables below, to be of no good whatever for the refiner. It follows that the introduction of sugar-beet as a field crop depends upon the introduction of the central factory system.

Tables showing the percentage composition of gurs made at Saharanpur from beet-roots in 1900

	312 1900 Yellow sugar beet	313 1900 White red top	314 1900 White gray top	15 1907 Klein Wanzleben	316 1900 White clean improved Vilmorin	317 1900 White green top Brabant	318 1900 French very rich
Cane sugar ...	62 55	65 16	65 58	60 56	67 55	66 62	68 28
Glucose ...	4 49	5 01	3 85	5 26	3 07	3 72	2 35
Water	10 62	15 73	13 91	22 17	19 76	17 48	13 60
Other matter principally "caramel"	16 34	13 20	16 46	13 01	9 62	12 18	10 37
Total	100 00	100 00	100 00	100 00	100 00	100 00	100 00

All the samples were badly burnt and hence contained a high proportion of caramel

Table showing the composition of beet-gur made at the Cawnpore Experimental Station in 1900

	Cane sugar	Glucose	Remarks.
	P c	P c	
Beet-Gur ..	93 94	3 88	In my opinion this beet sugar would be useless to the refiner (Sd) J WALTER LEATHER

Cost of cultivation.—The figures given below are approximate estimates meant as a rough guide for forming a general notion of the probable cost of producing the crop, those relating to the cost of labour are what prevail in the neighbourhood of Cawnpore city and are therefore somewhat higher than what prevail in the provinces as a whole.

Cost of cultivation per acre.

	Rs	a	p
Digging the land with phaora ... ... 10 to 16	0	0	
Four ploughings with the native plough and levelling, etc.	4	0	0
Ridging by manual labour	3	0	0
Seed ...	10	0	0
Sowing by hand	1	4	0
Tanning	2	0	0
Earthing	3	0	0
Three weedings and hoeings including a second earthing,	7	0	0
Five waterings by lifting canal water ...	7	8	0
Harvesting by digging with phaora	3	8	0
Rent ... ... 15 to 30	0	0	
Canal dues ...	2	0	0
Miscellaneous, as carting to the factory, watching, etc ,,	5	0	0
Total Rs. 73 to 93	0	0	

In making allowance for the comparatively higher wages in the neighbourhood of Cawnpore, it should be remembered that the crop, if grown, must be more or less near the town where the factory will be started, and that should many cultivators in any particular neighbourhood begin to grow the crop on a large scale to supply a factory, the chances are that wages would rise in the busy season

It will be noticed that no provision has been made for manure, properly speaking half the cost of the organic manure applied to the previous crop should be charged to beet, but it is almost impossible to give figures of general value for the cost of manure.

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